



**UNIVERSITÉ
DE GENÈVE**

FACULTÉ DES SCIENCES

Department of Earth Sciences



The GEothermie2020 exploration program in Canton of Geneva(CH) six years down the road: Opportunities and challenges

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REPUBLIQUE
ET CANTON
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 swissuniversity.ch



Munich

Zurich

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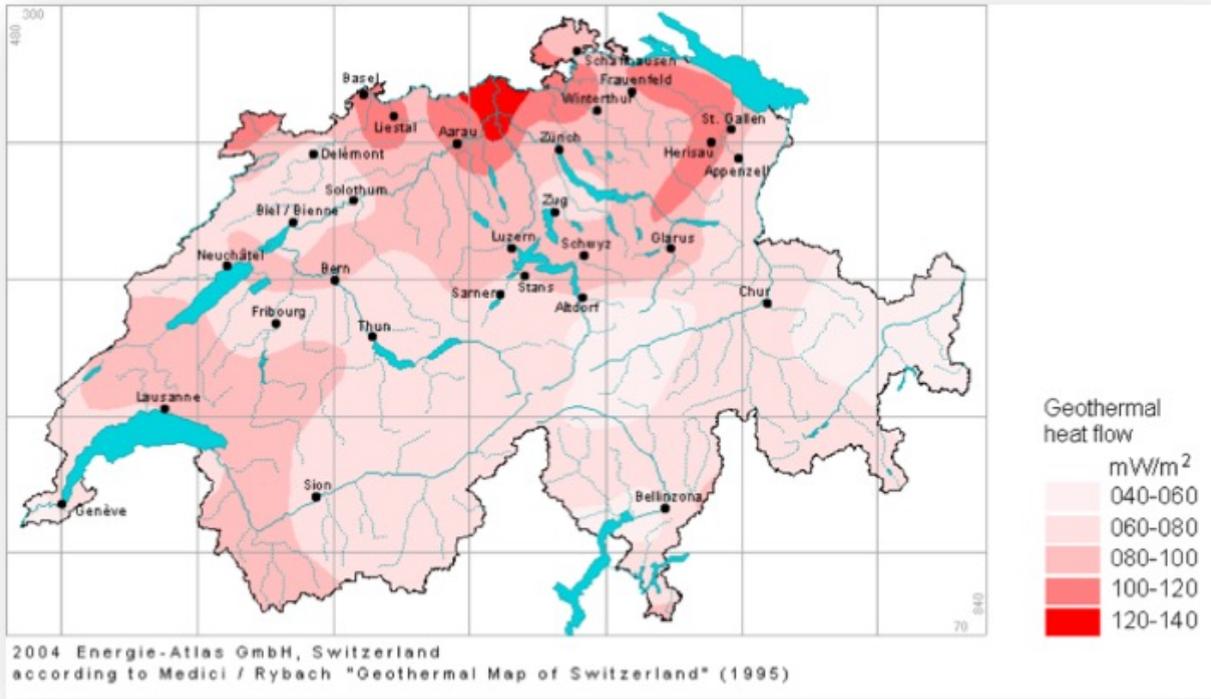
Milan

Turin

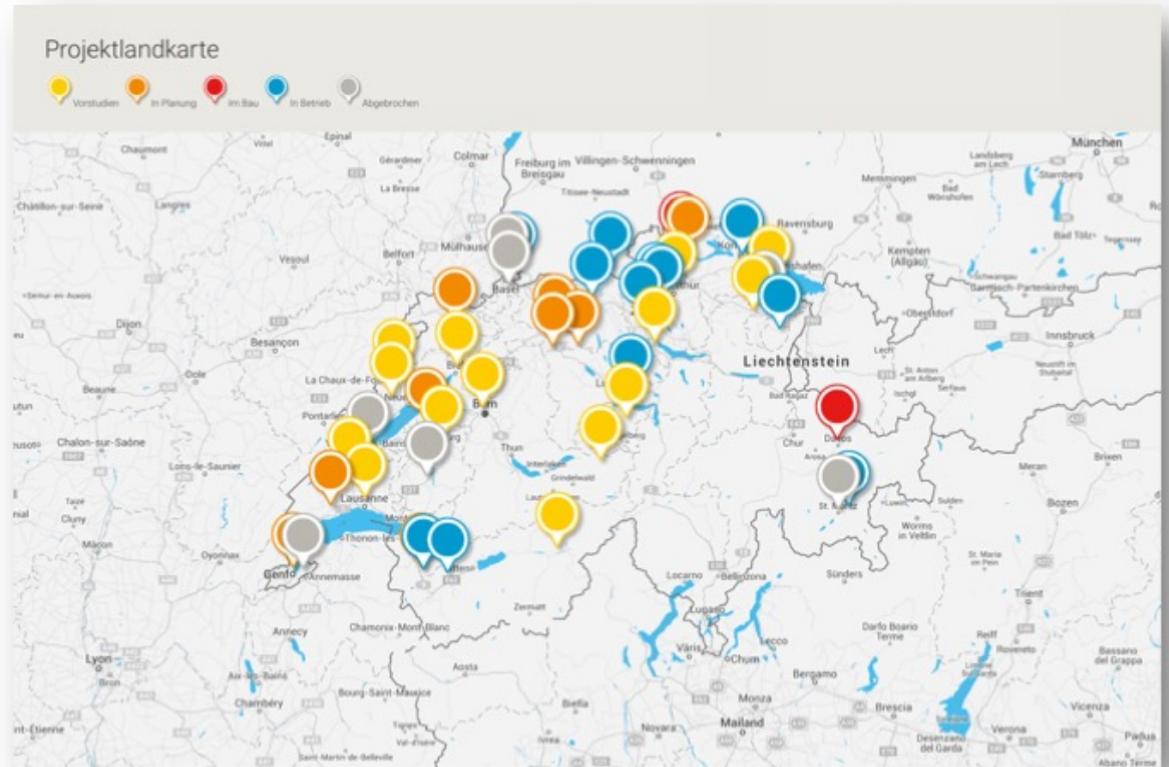
Zagreb

ALPS

- General Swiss Context
- Canton of Geneva & GEothermie 2020
- Geothermal Activity & Results
- Perspective & Conclusions

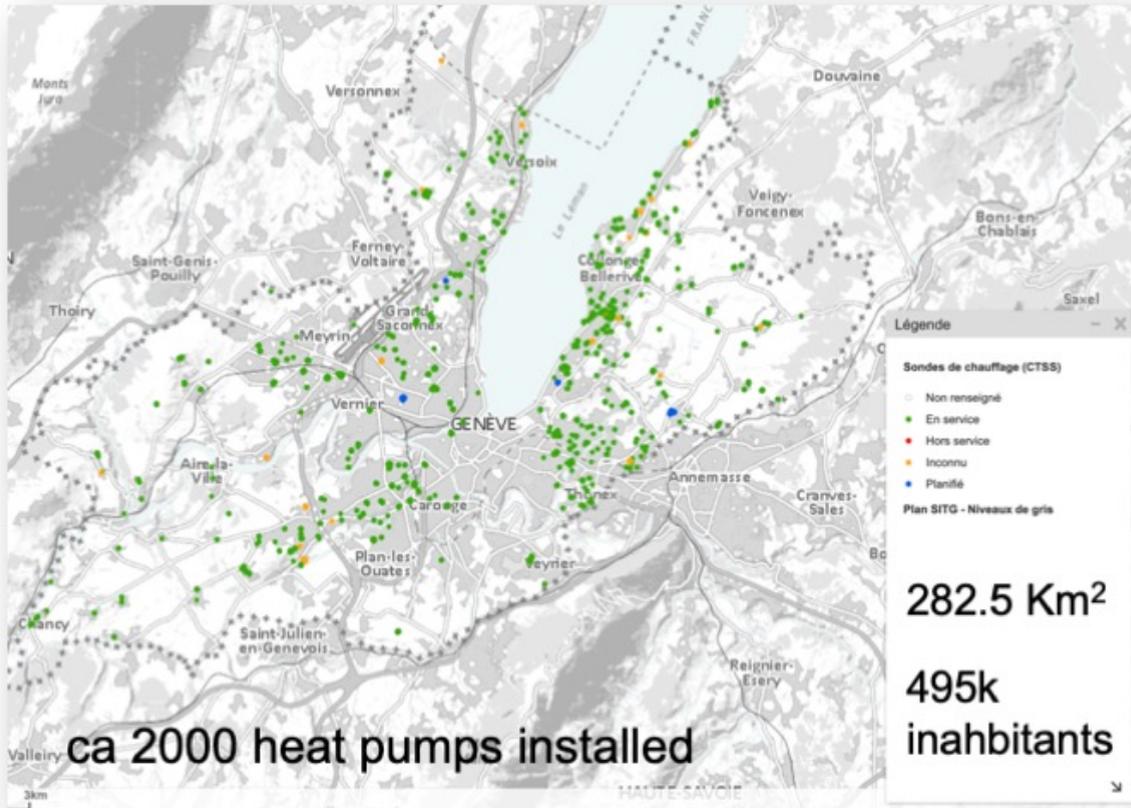


Geothermal Activities in Switzerland (Power & Heat)



- 1993 Thônex
- 1994 Riehen
- 2006 Basel
- 2011 Schlattingen
- 2012 St. Gallen

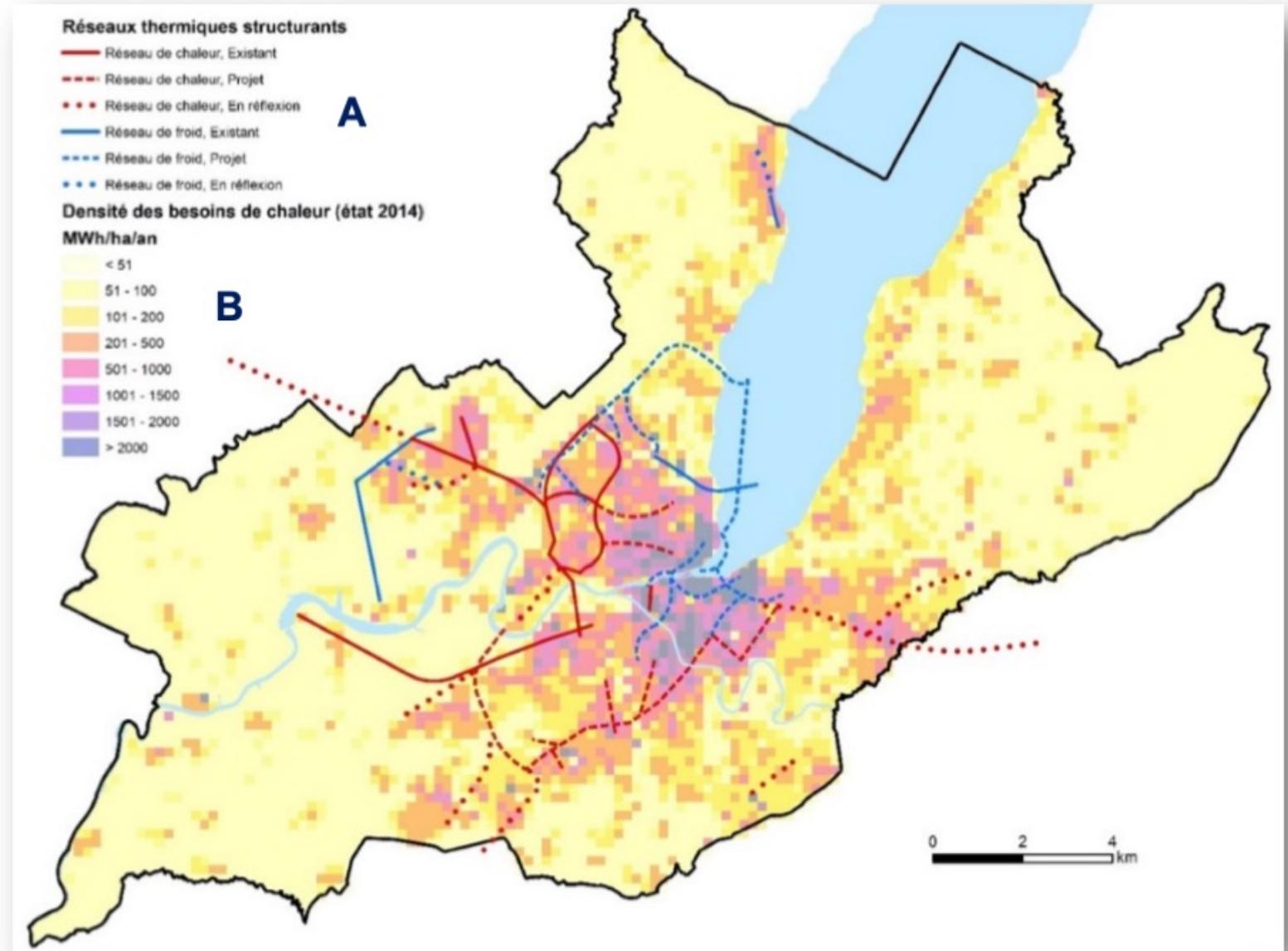
Low Enthalpy energy well developed in the Canton of Geneva for both heating and cooling of private and office buildings (Geothermal and Lake Geneva Water)



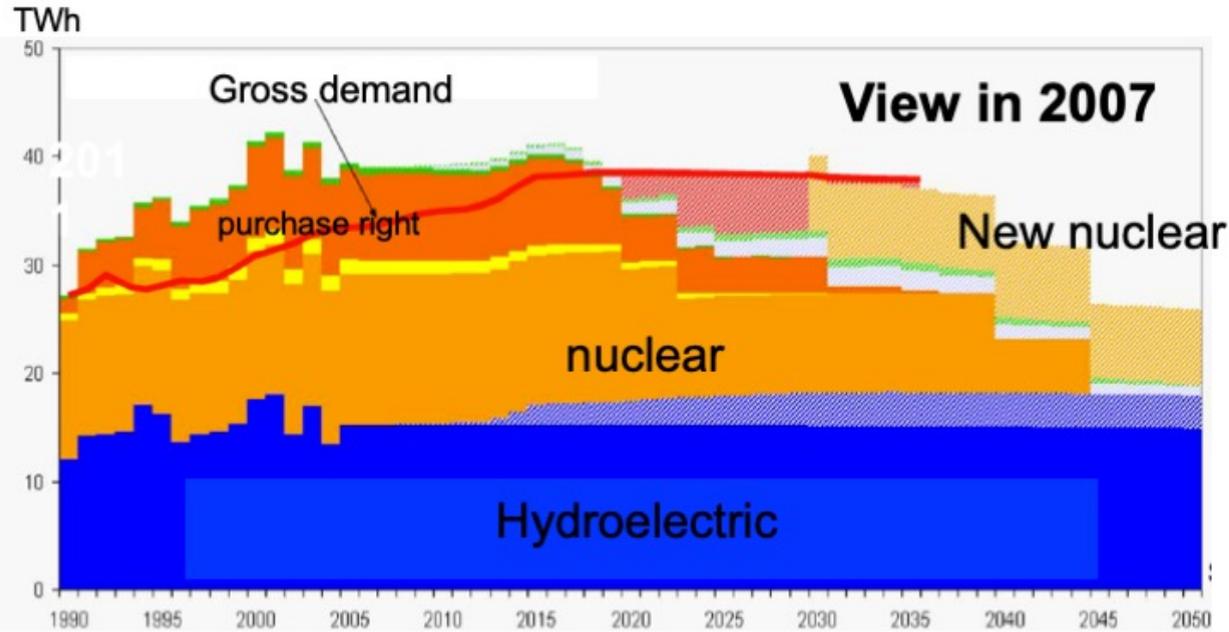
**Well developed heat district network
yet...
the Directive for the Cantonal Planning
of thermal distribution (PDER) is in the
process of being finalized.**

Principles of territorial consistency:
favors the deployment of the main
thermal networks and support of
medium-depth geothermal energy
implementation

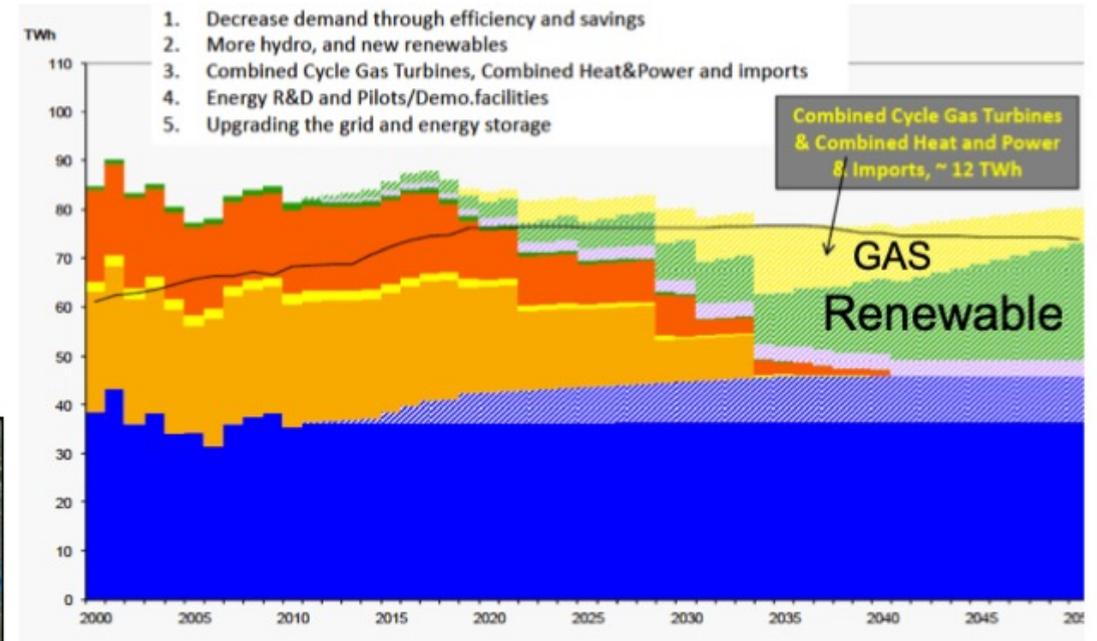
A principle of merit order: the
medium-depth geothermal energy
represents a priority energy source
after HT waste heat



A: Thermal network, B: Density of heat requirement (MWh/ha/year)



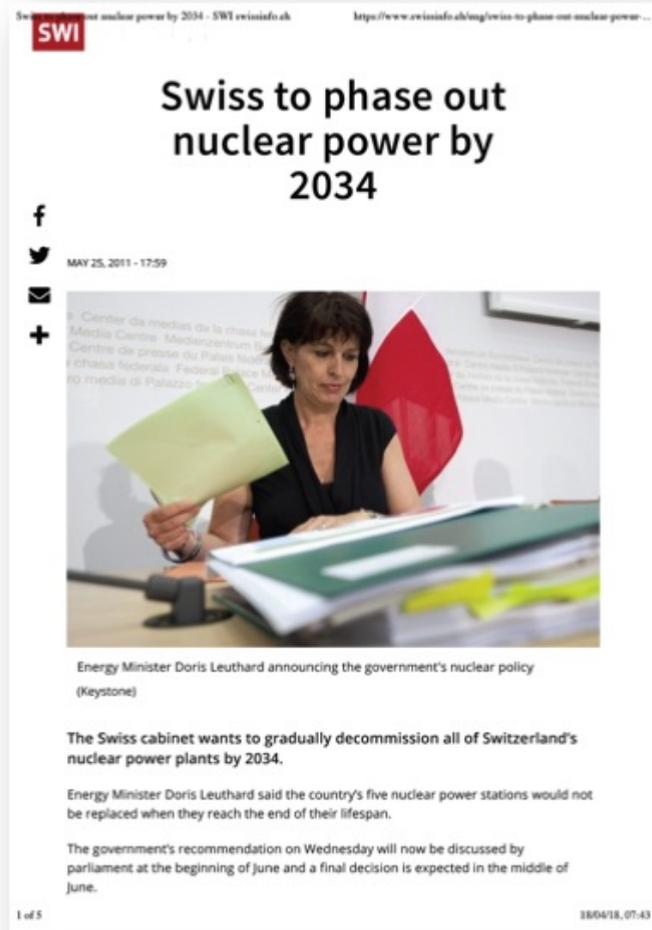
Swiss Energy Strategy 2050: scenario for power supply and demand.



View after 2011

Source: SFOE 2012

THE FEDERAL CONTEXT



May 2011

Results of the 2017 May vote for the 2050 Swiss Energy Strategy

which aims at phasing out Nuclear Power plants by increasing renewables for

- Heating & cooling
- Power generation
- Energy Storage
- Energy Efficiency



P&D Projects

- Up to 40% of the non-amortizable additional cost (costs beyond conventional technologies or systems)
- Costs for the development, procurement and materials, construction optimization, operation, monitoring, documentation and communication.
- Available to Companies, Tertiary education sector (UAS, U, ETH), public entities etc.
- No limits regarding project duration and financial scope of projects

CO₂ - Ordinance

(since Jan 1st, 2018)

- Up to 60% of the prospection and exploration costs
- Costs for the surface data acquisition, procurement and materials, drilling operations, well testing and logging

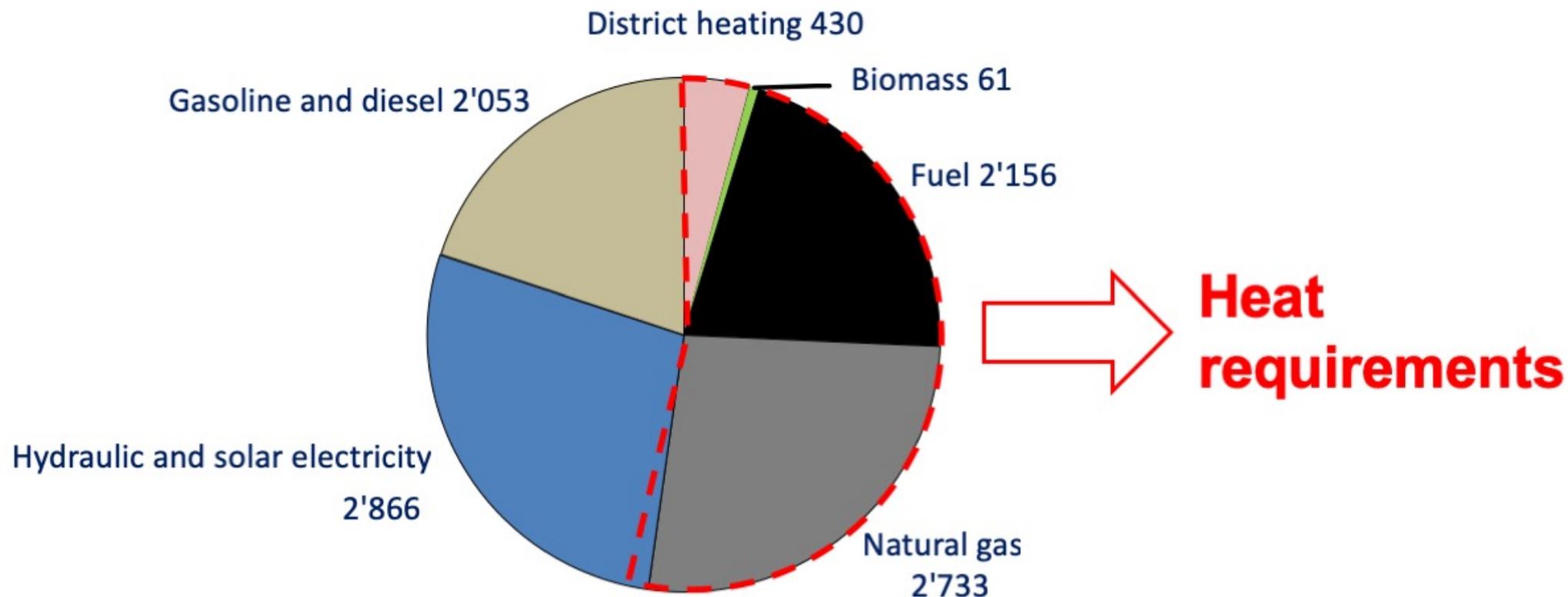
Swiss Federal Office of Energy SFOE



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Energy context in the Canton of Geneva

Final energy consumption in the Canton in 2014 (GWh/an)



Data source: OCSTAT, SIG, OCEN, SITG

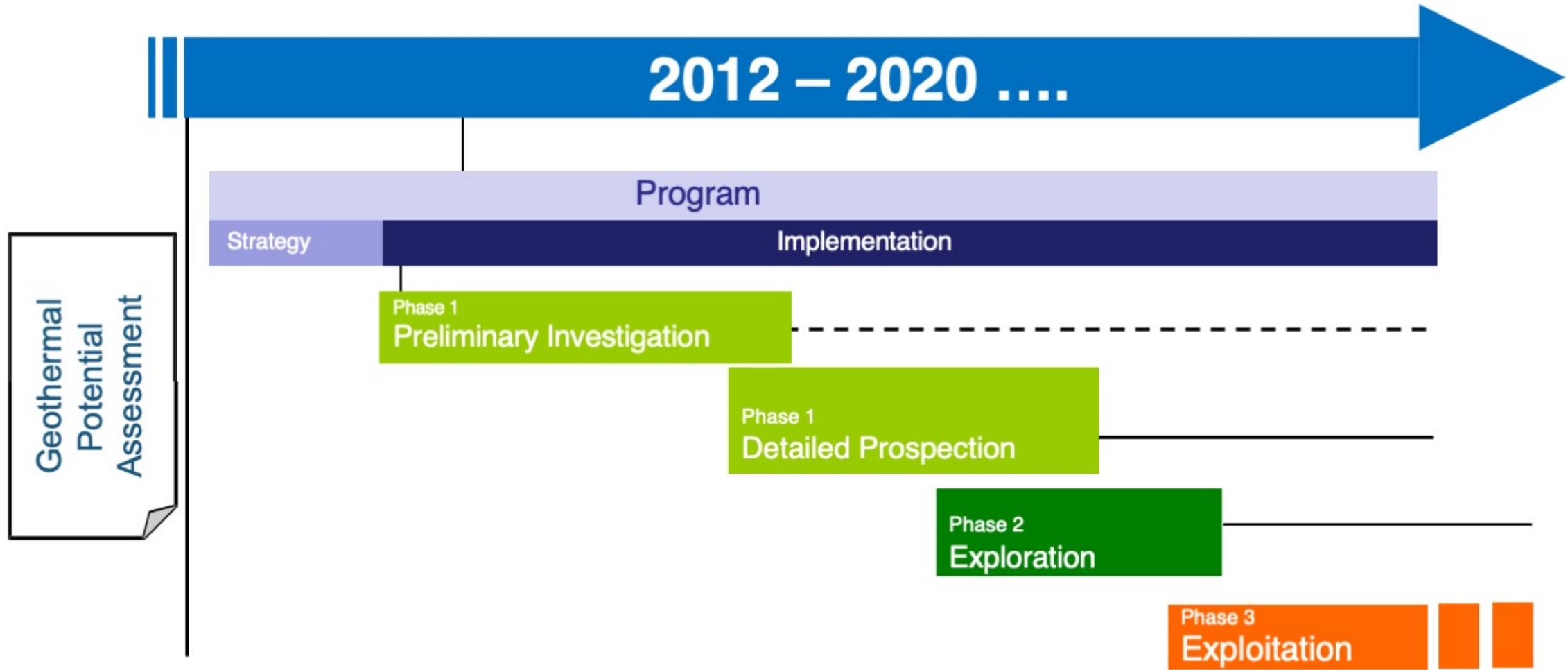
With applied heating climatic correction

Aviation fuel not included

Source graphique : Loïc Quiquerez 2017, <https://archive-ouverte.unige.ch/unige:93931>



GEothermie 2020” program: an integrated approach



Modified after Andenmatten
Berthoud, 2014



GEothermie 2020” program: an integrated approach



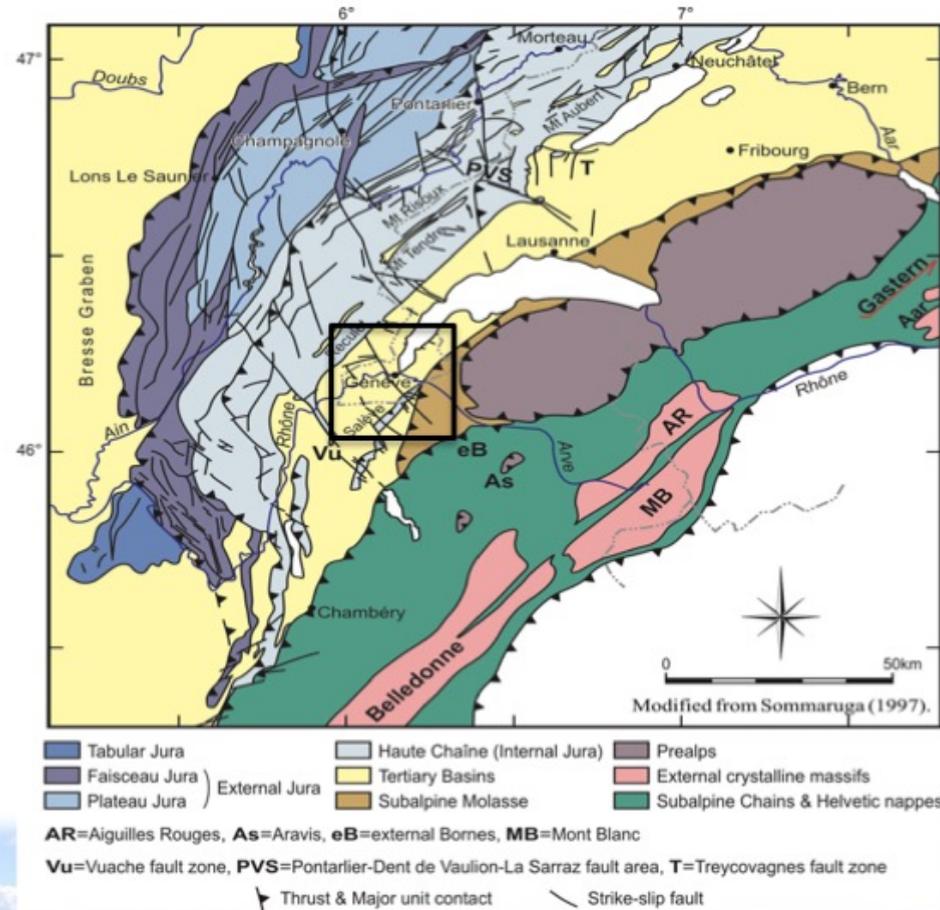
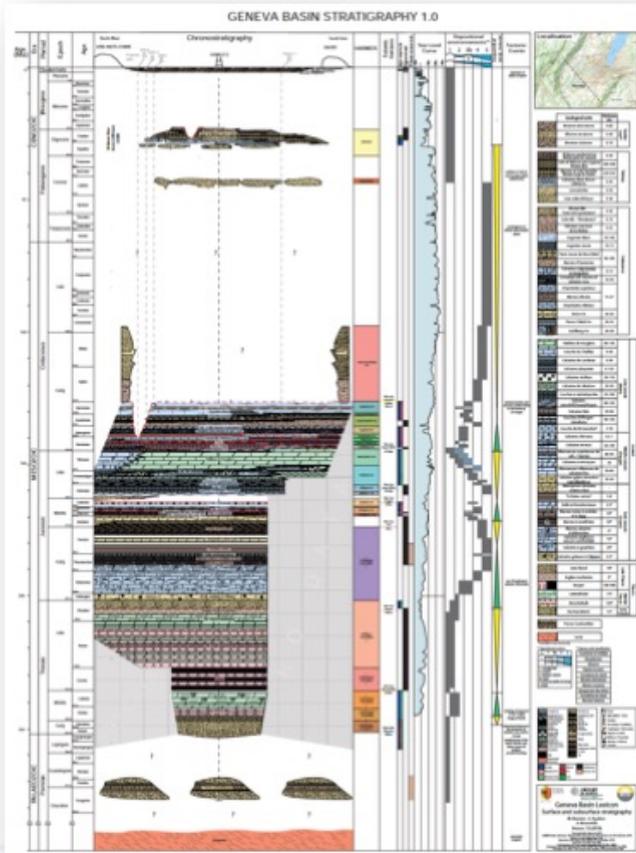
Modified after Andenmatten
Berthoud, 2014

General framework



General framework

Rusillon et al. 2017



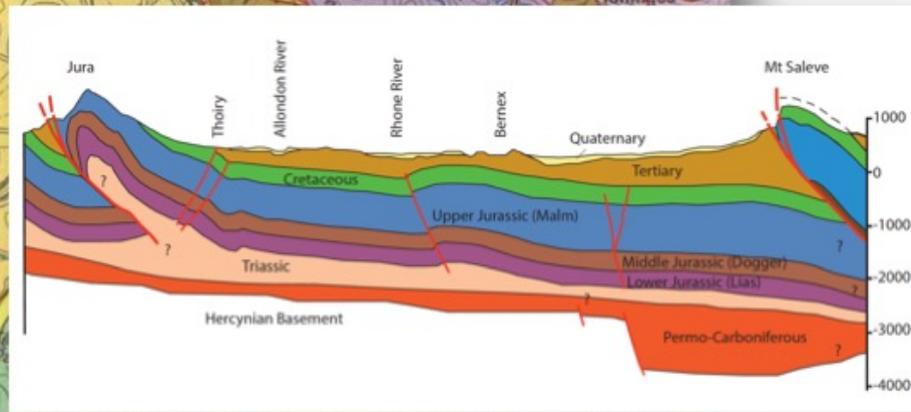
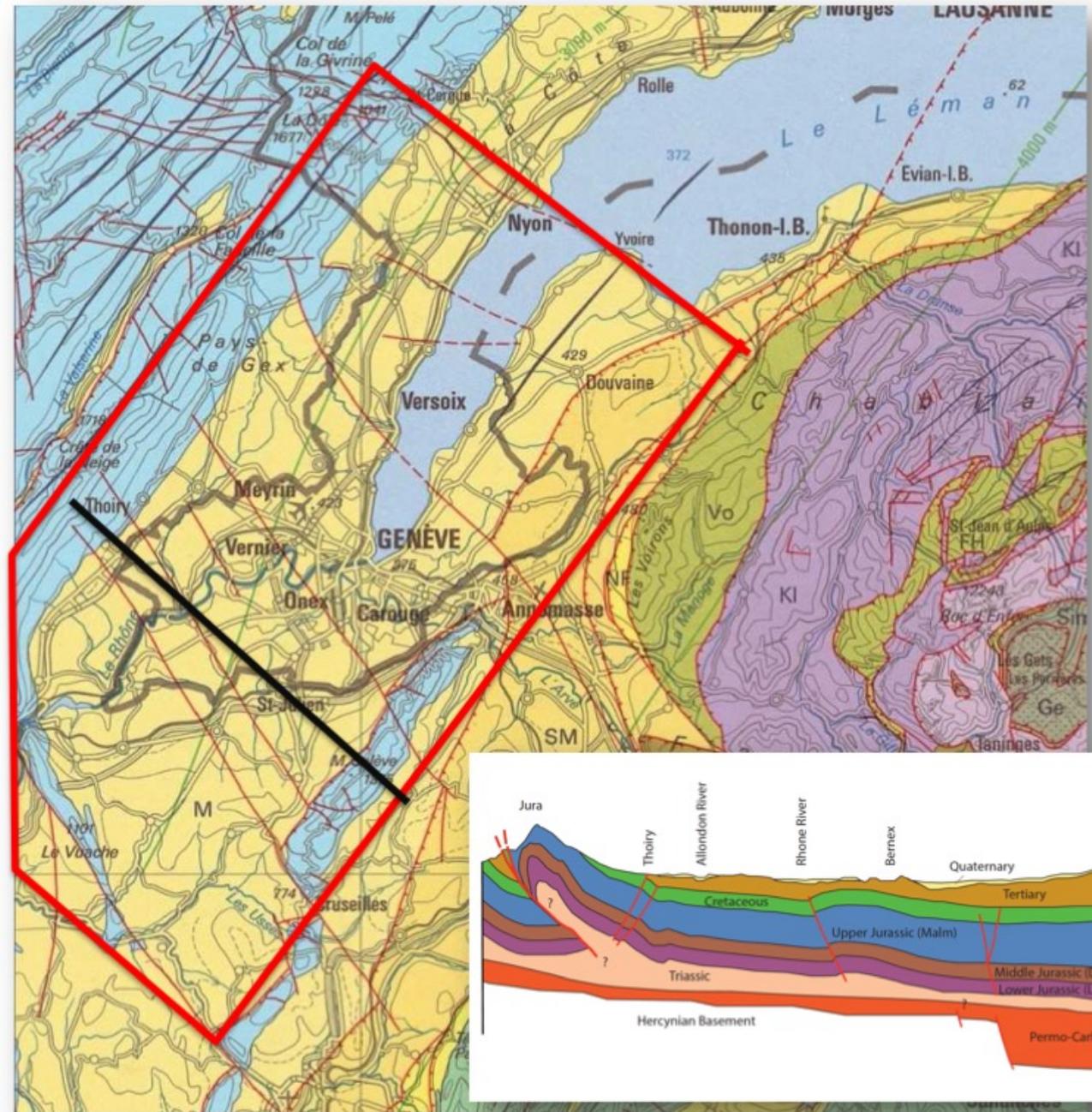
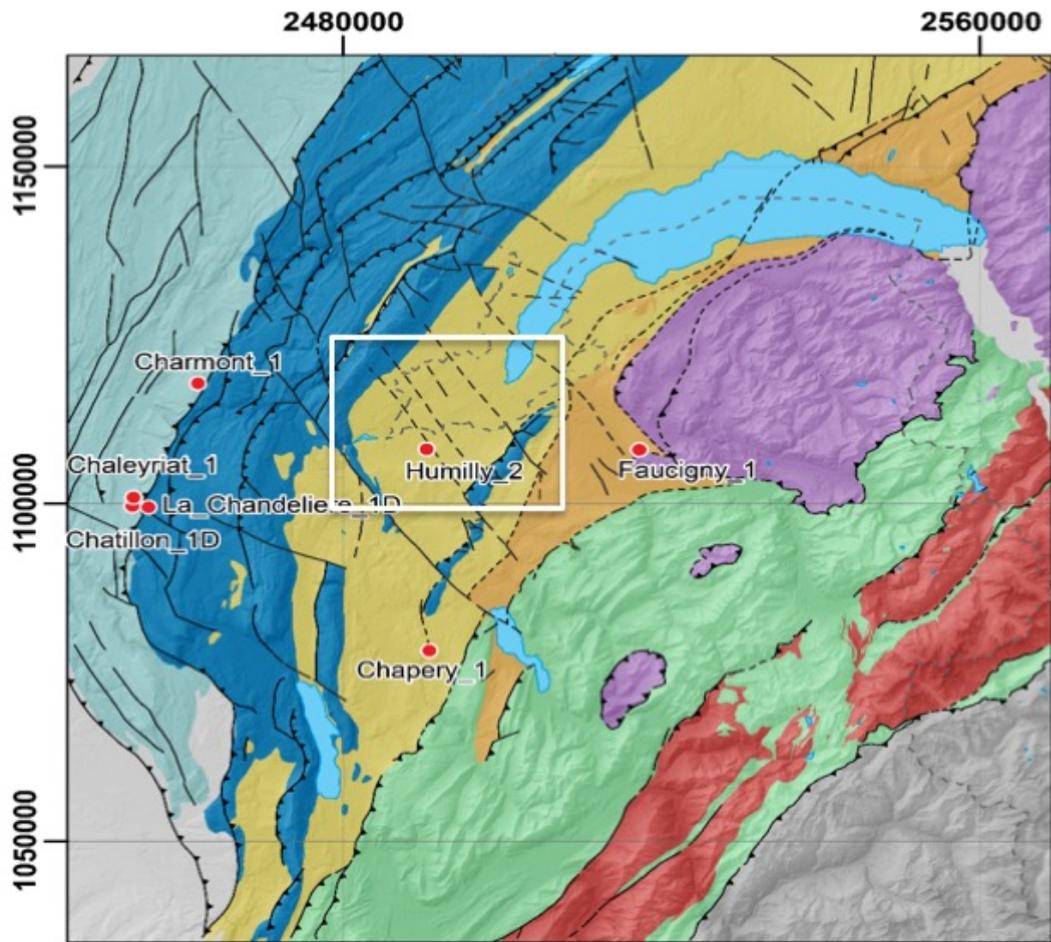
Vuache

Jura

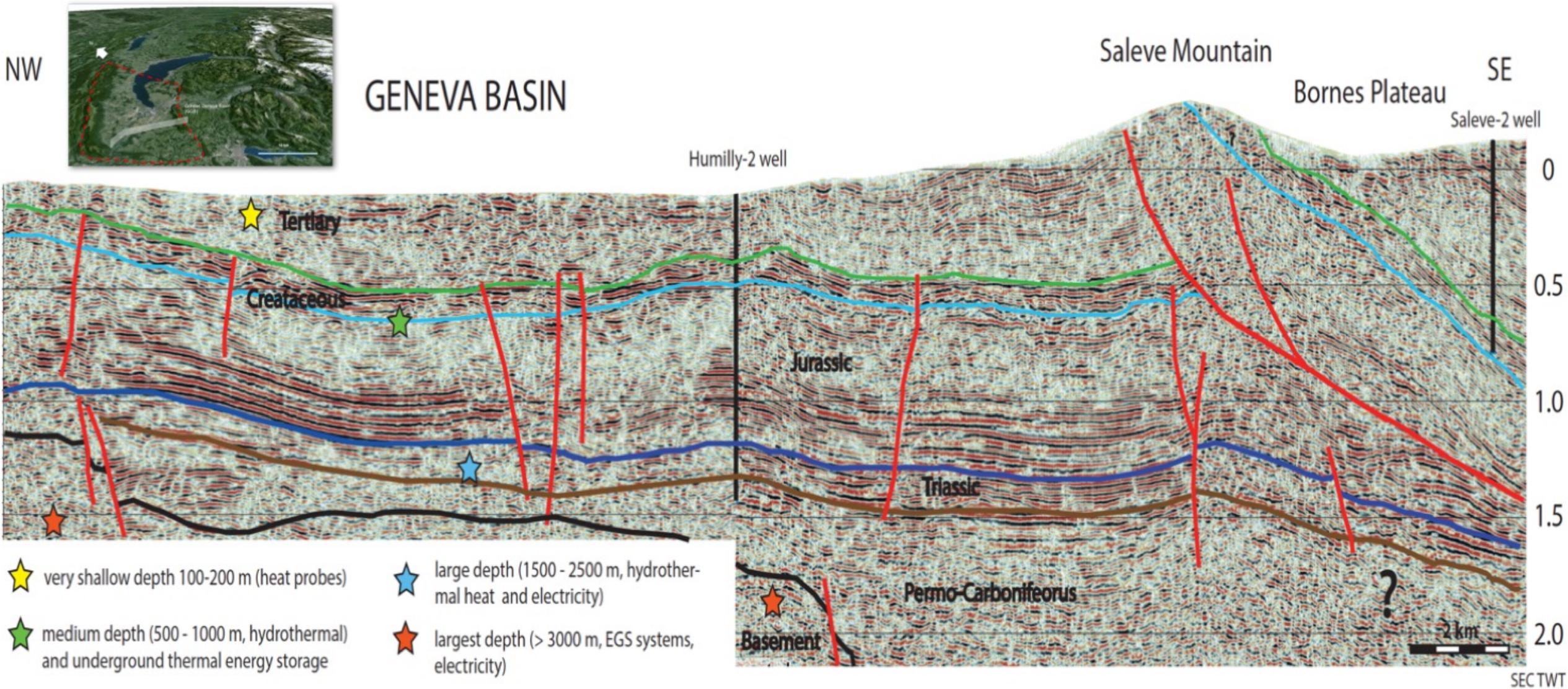
Swiss Plateau

Saleve

Saleve



Western Switzerland Geological framework

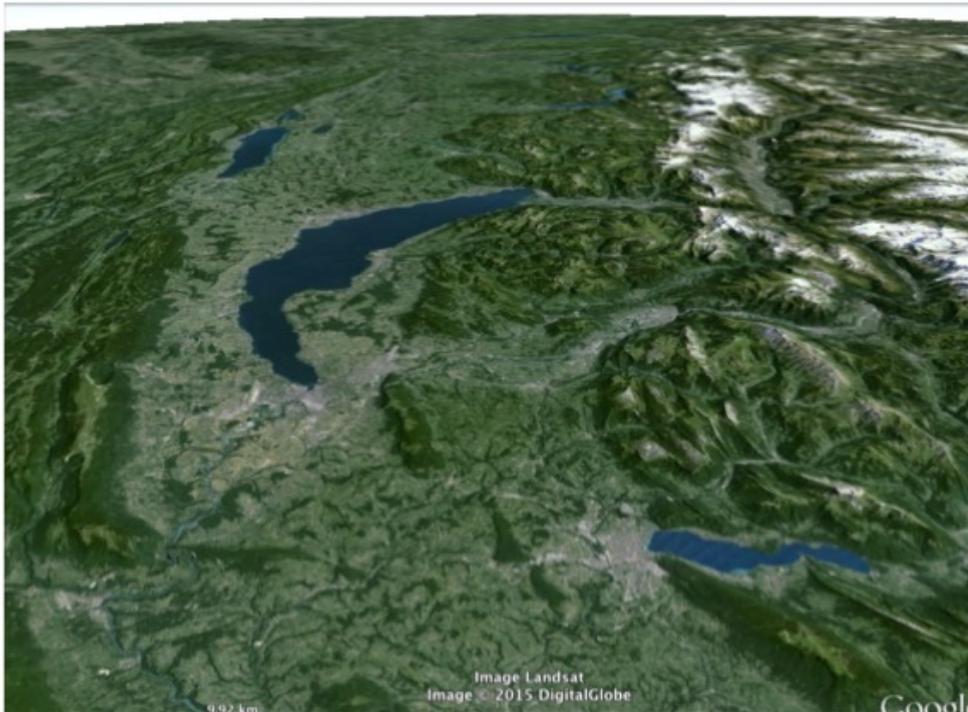


Seismic cross section across the Geneva Basin with indication of main stratigraphic units and indicative location of key reservoirs at different depths for different exploitation of geothermal energy resources (heat or electricity). After Moscariello, 2016, EGC proceedings.

GGB Geothermal Exploration: a glance into the past

Hydrothermal sources associated with mineral-rich hot springs (up to 23° C at surface) have been known since the **XVth century**.

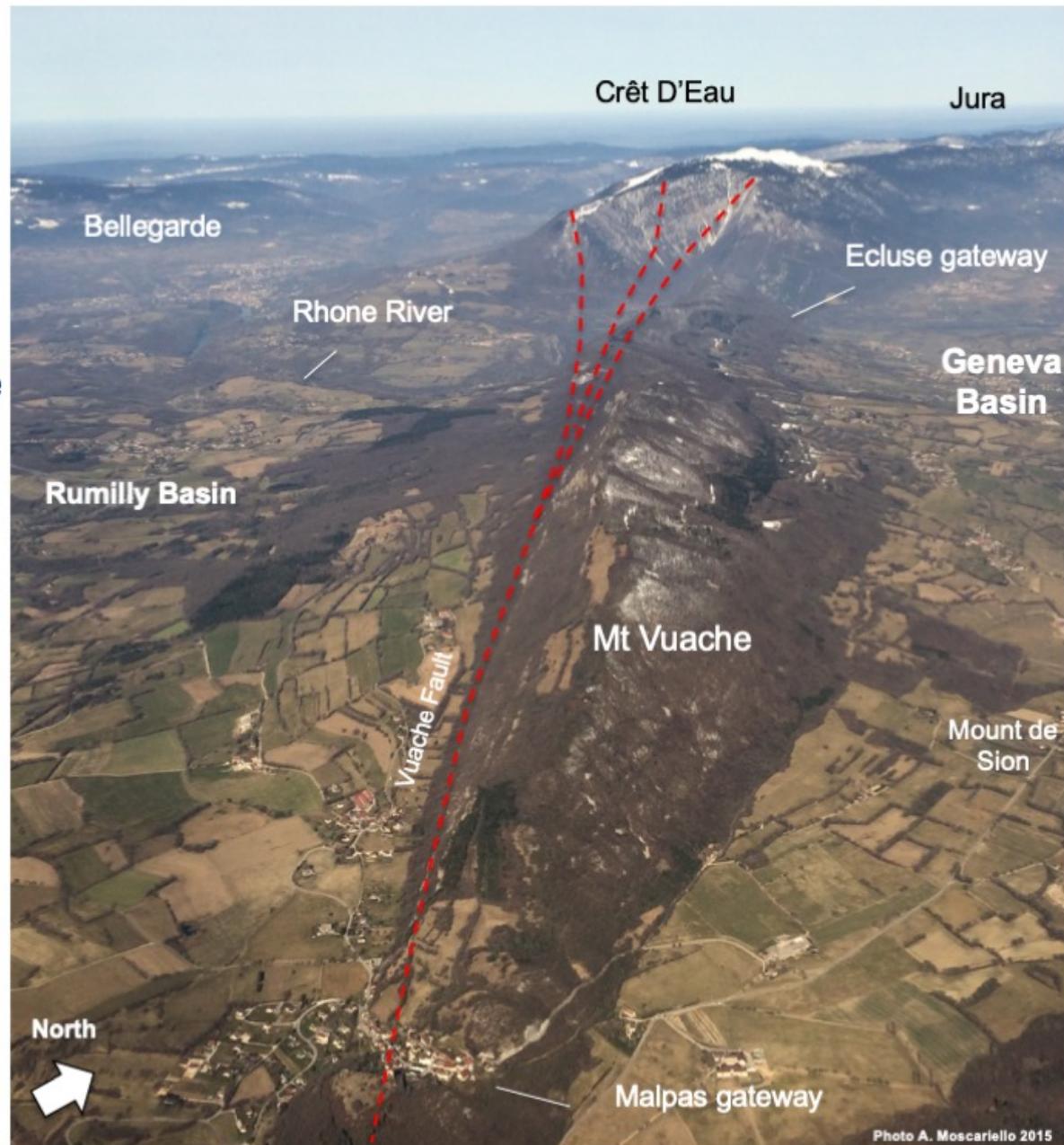
Likely associated with large fault systems as indicated by the effects on Bromines spring following the Vuache Fault reactivation in 1996 (M1:5.3)



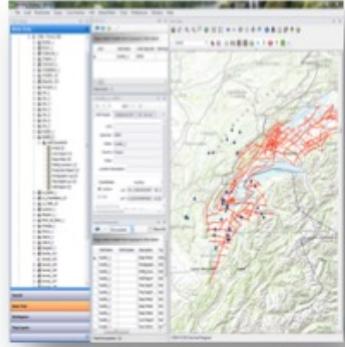
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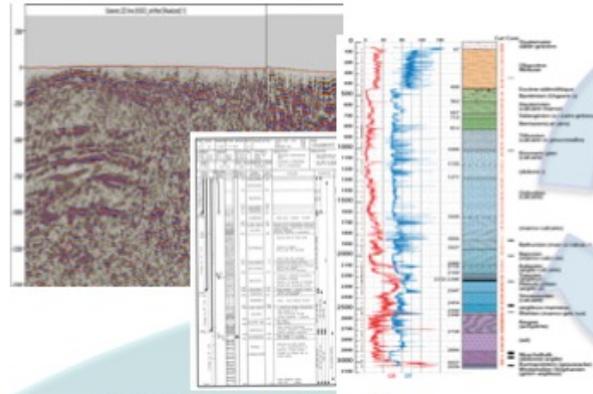
Likely associated with large fault systems as indicated by the effects on Bromines spring following the Vuache Fault reactivation in 1996 (**M1:5.3**)



UNIGE WORKFLOW



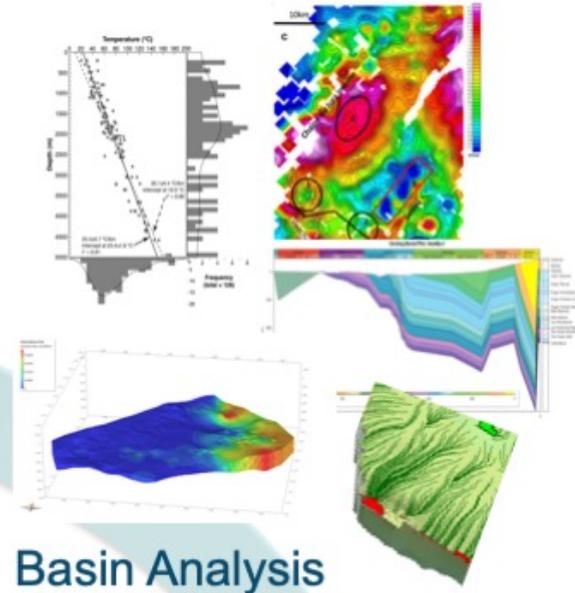
Knowledge Base



Data evaluation



Data acquisition



Basin Analysis
(Configuration, Fluids and
Temperature Distribution)

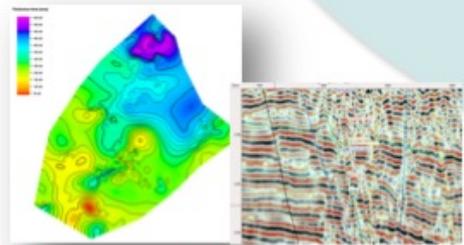


Drilling

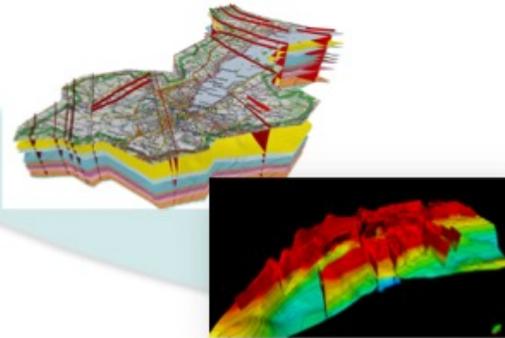
2014



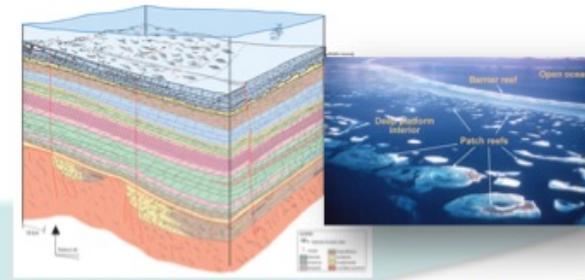
2020...



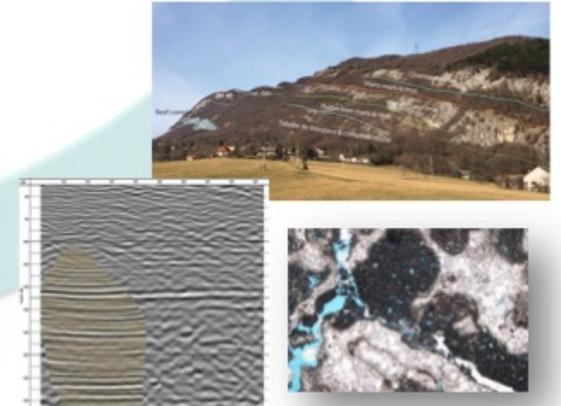
Prospect Identification
and Assessment (PBE)



3D Reservoir Modelling

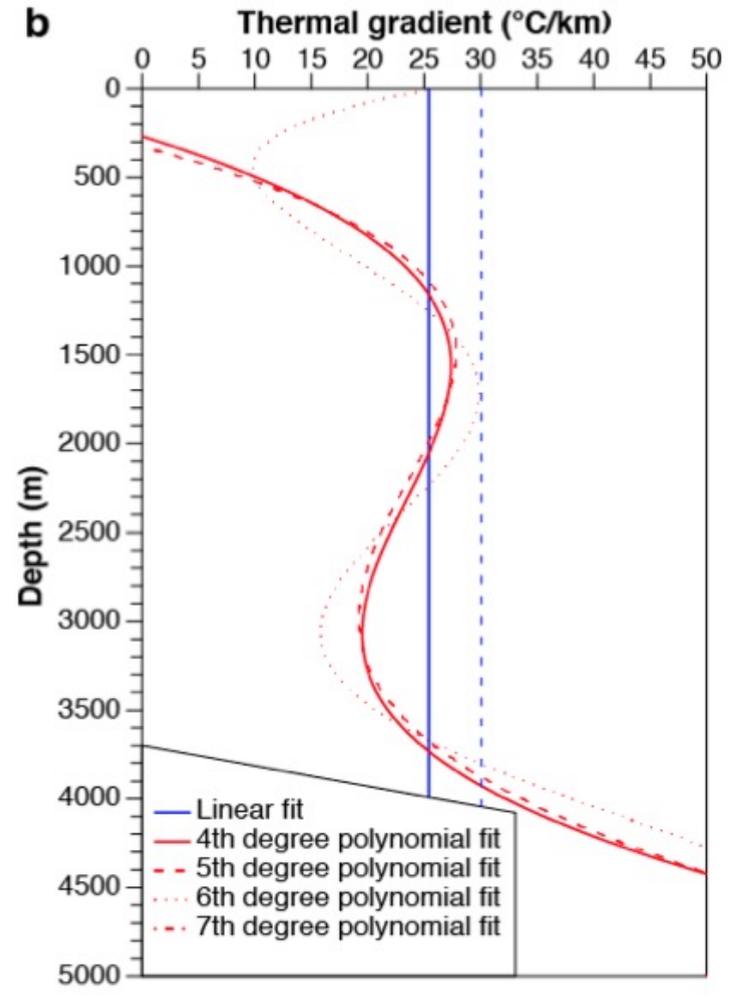
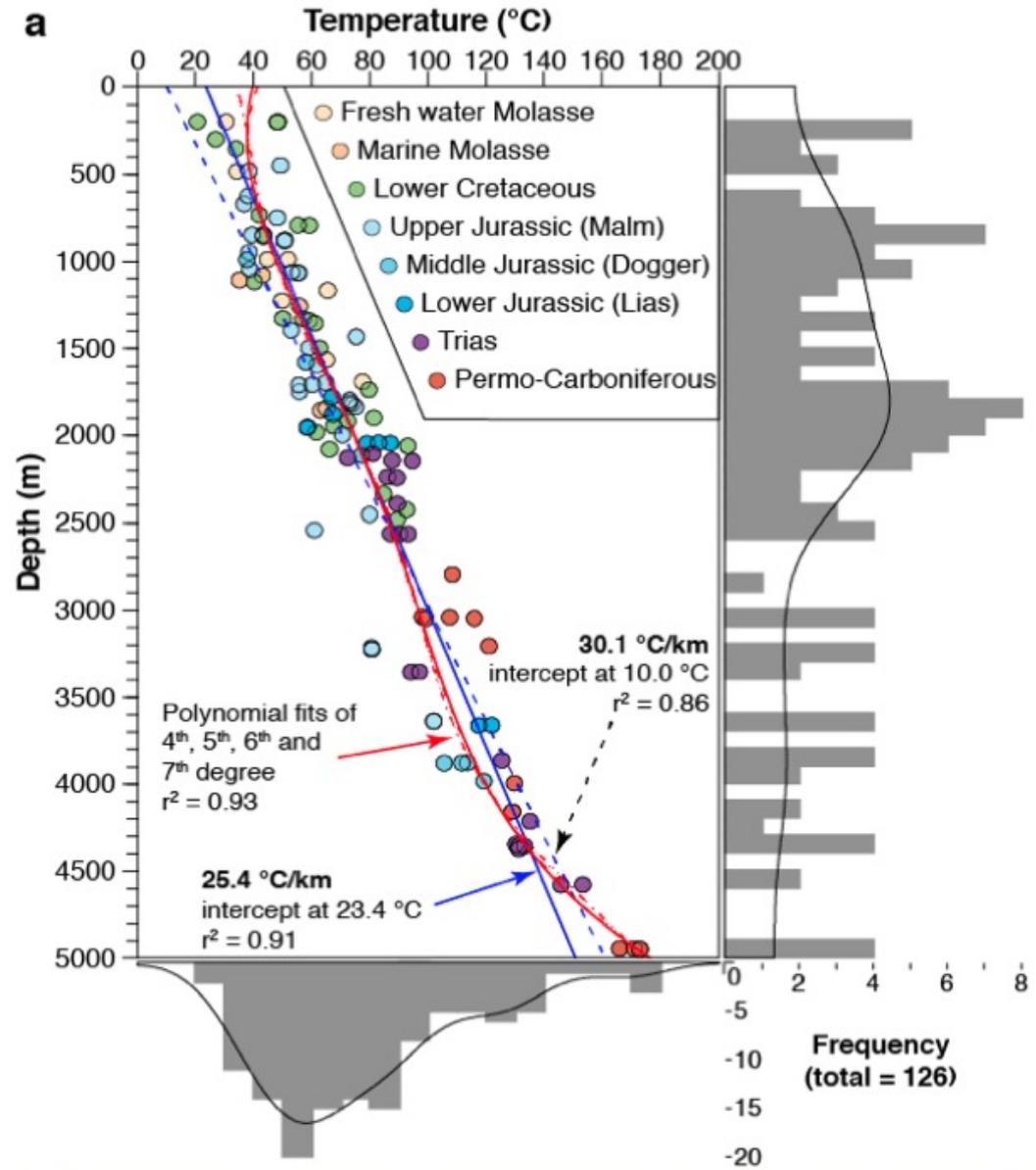


Conceptual Geological Model
(geometry & properties)



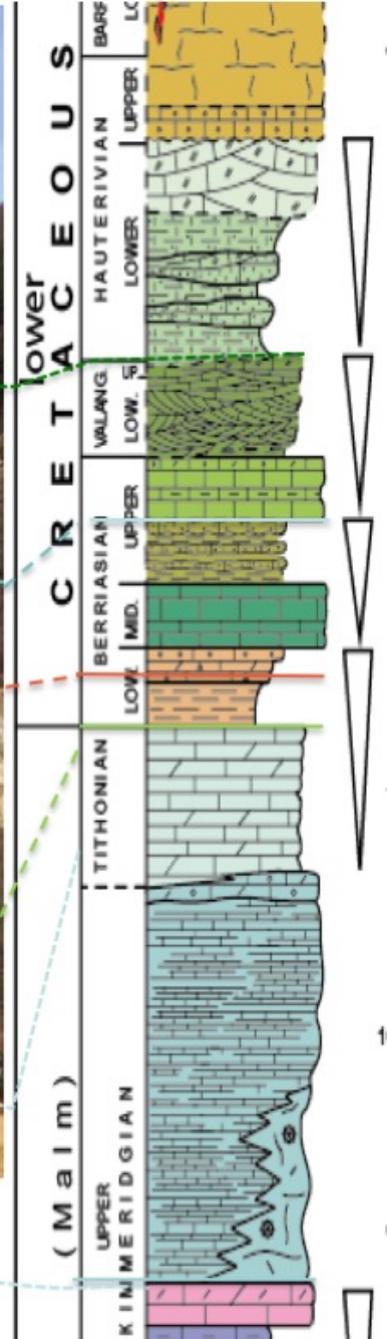
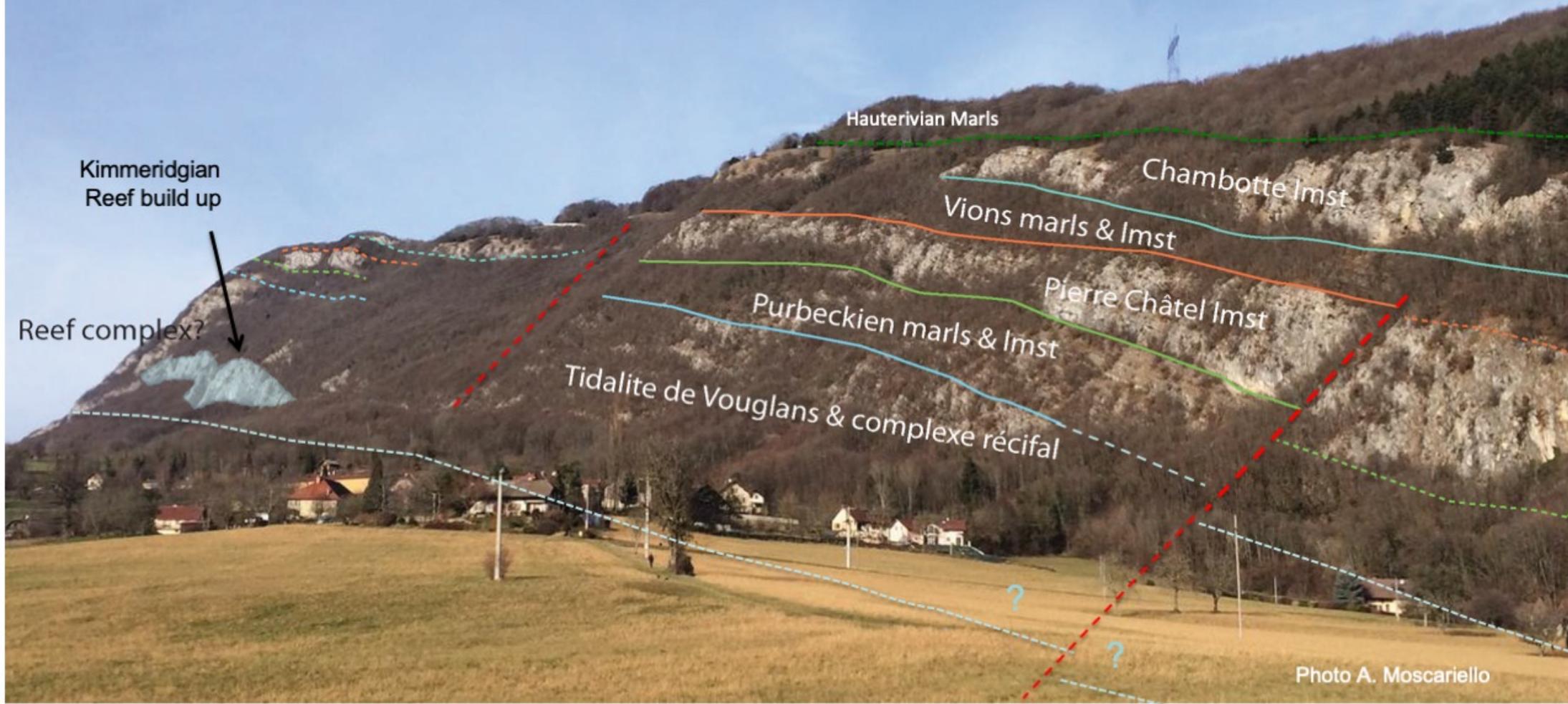
Reservoir characterisation

Is the Geneva area subsurface hot enough ?

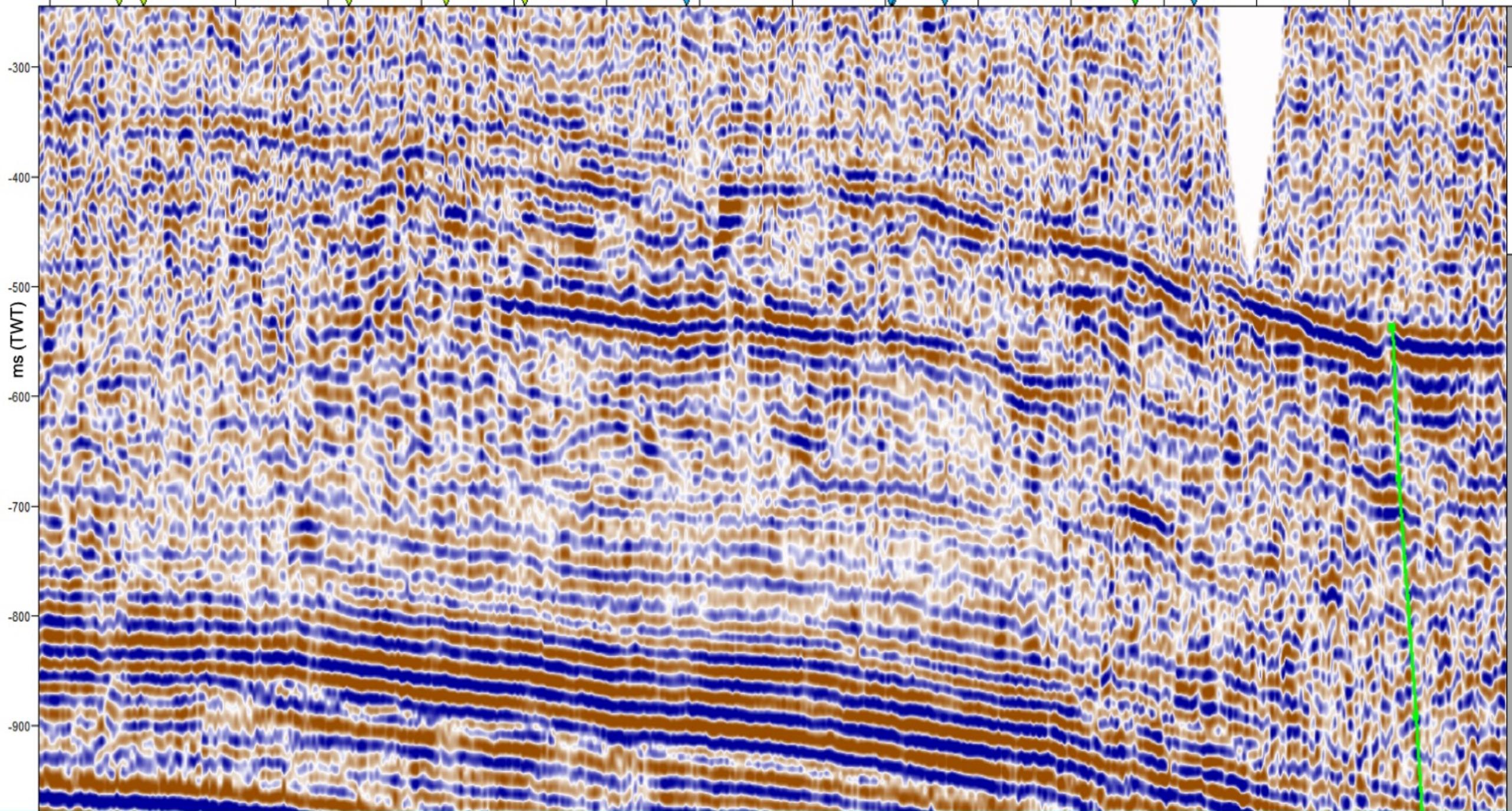


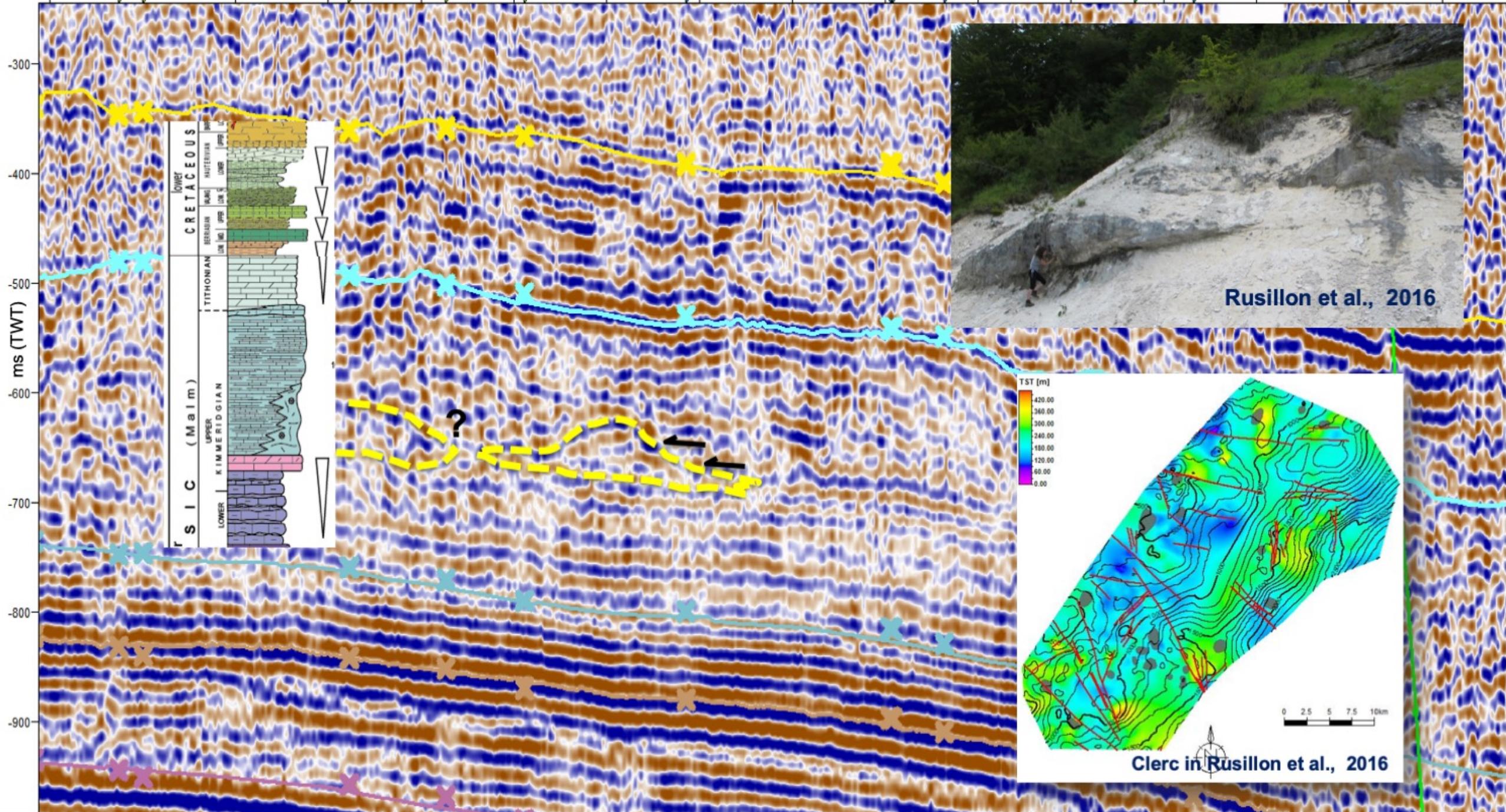
Chelle-Michou et al., 2014, Geothermics

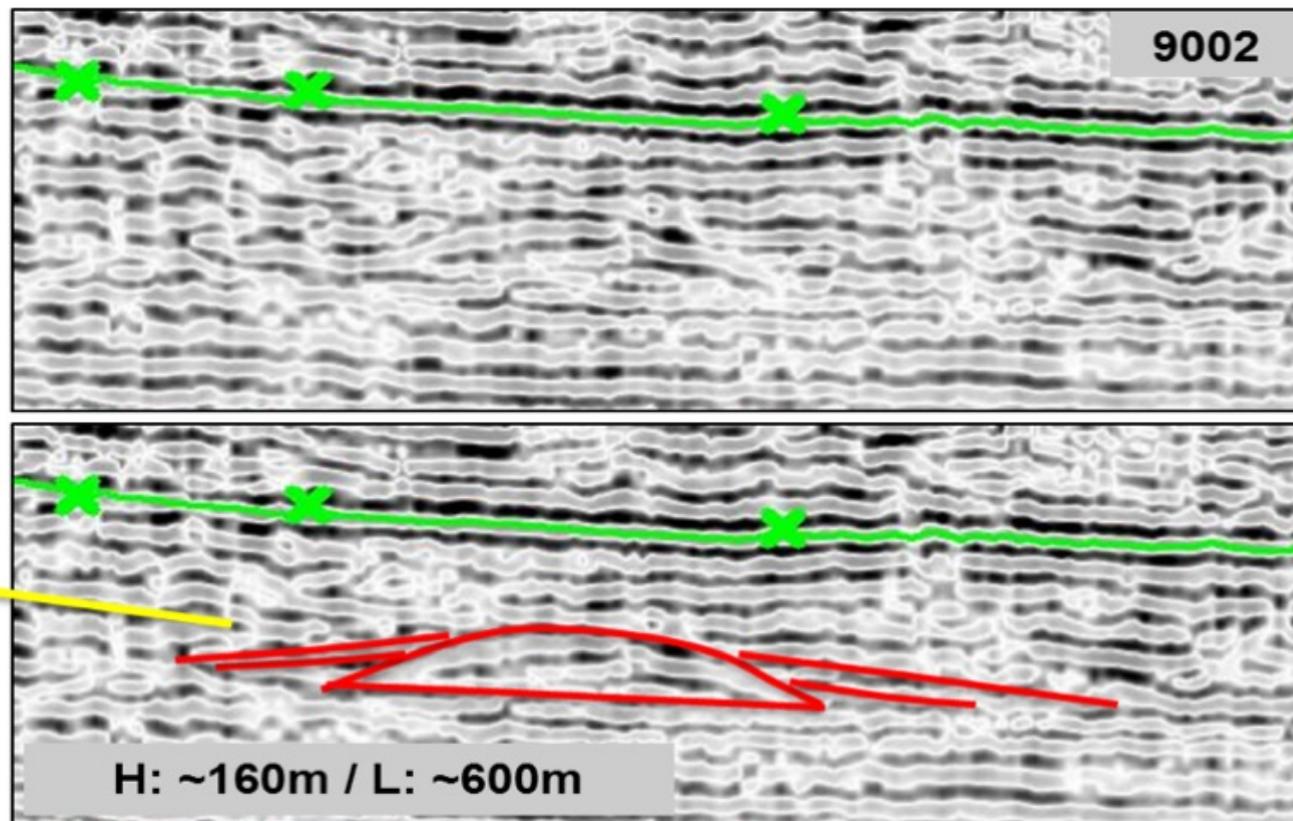
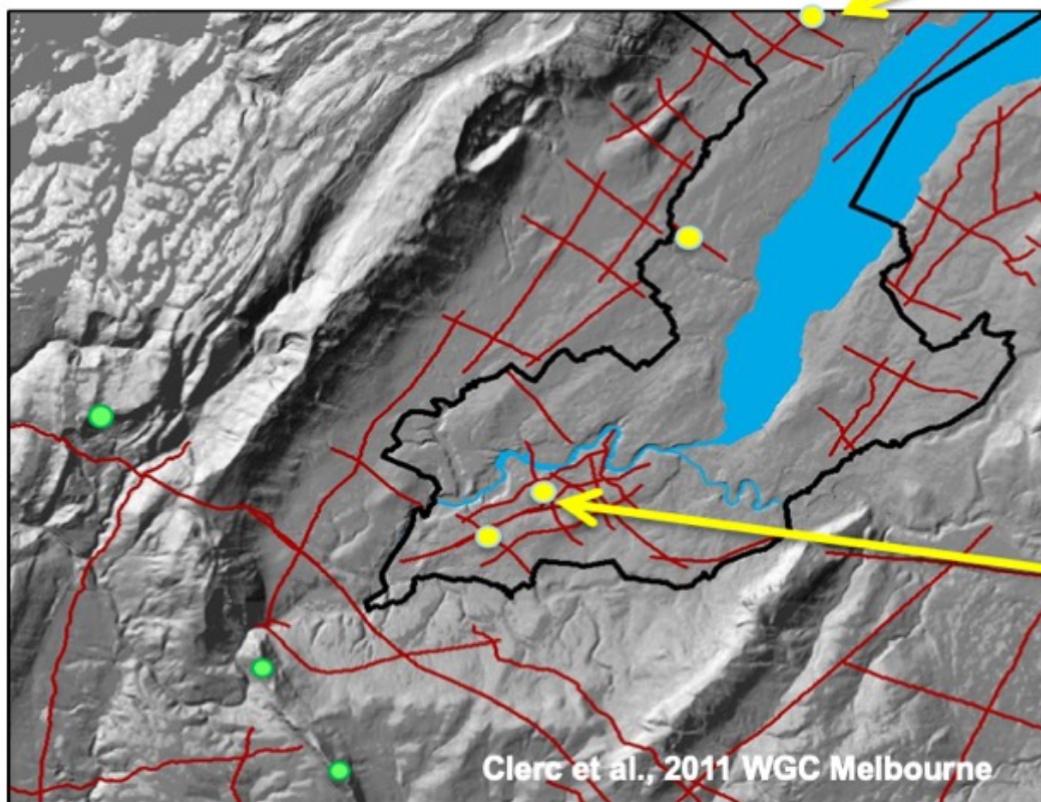
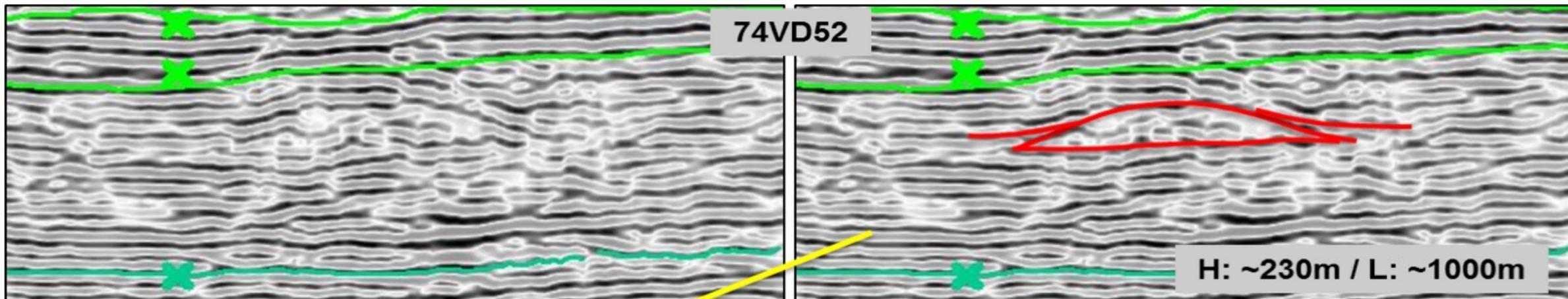
DATA EVALUATION: OUTCROP SEISMIC CALIBRATION



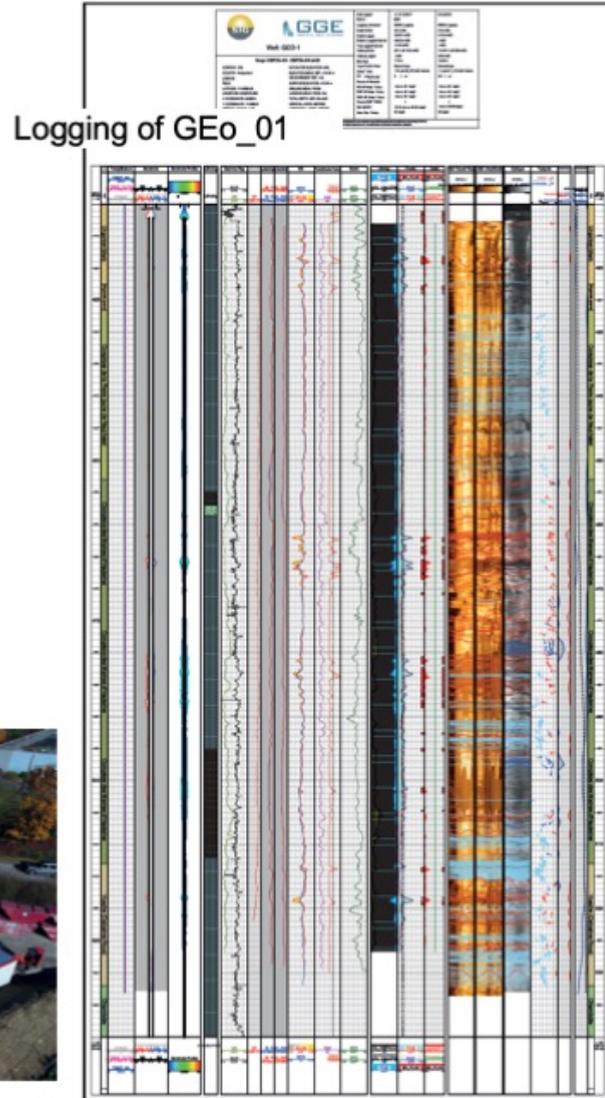
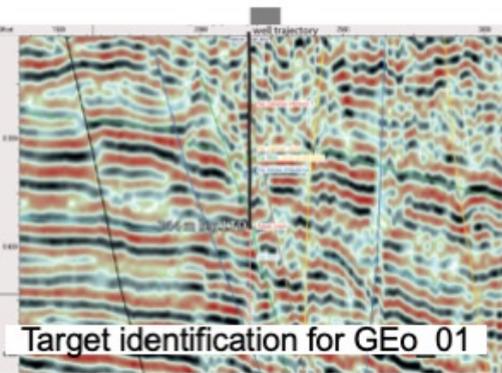
Reservoir stratigraphy and architecture:
Sedimentary body geometry,
Changes in vertical stacking pattern and lateral sediment composition (facies)..







Geneva basin-scale hydrothermal play for heat extraction and storage



Demo project: Seasonal TES from waste plant *Results for GGeo_01:*

- Depth: 744m b.g.l. (650m was the original plan)
- Temperature: 33°C
- Flowrate: 50l/s artesian flow
- Reservoir type: Fractured Lower Cretaceous / Upper Jurassic limestone





2012 – 2020 ...



Drilling activities

Shallow targets
(300-1000 m)

Mid range targets
(1000-1500 m)

2020-2022

Deep targets
(2500-3500 m)

Geo-01
2018



GEo-02
2019



Continuous activities

Reservoir characterisation

Structural modeling at regional scale

Geochemical fingerprinting

Seismic monitoring

Field Lab Activities

CSEM / EM survey

Walk Above VSP (Thonex-1)

Gravity Surveys

Long term well test and Monitoring

Fiber optic VSP

3D seismic survey

Research Projects



IMAGE



Horizon 2020

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

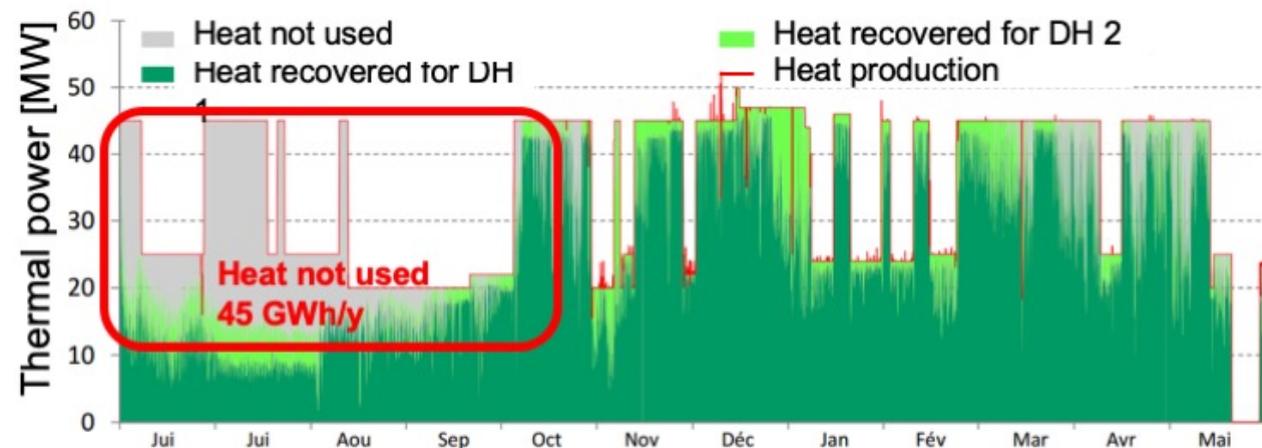
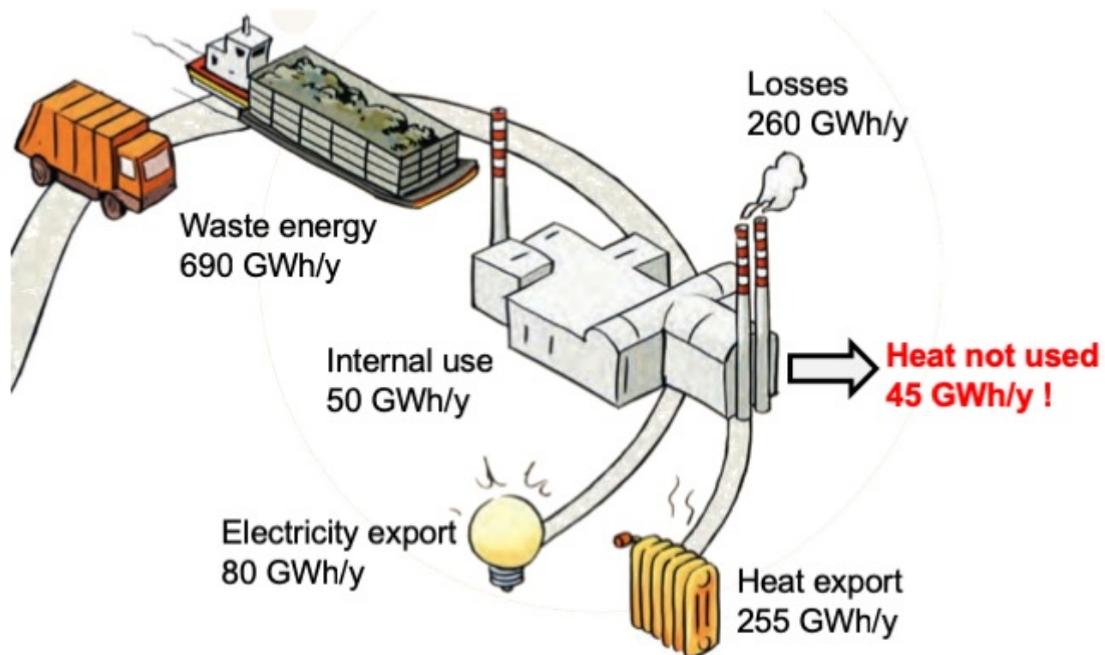


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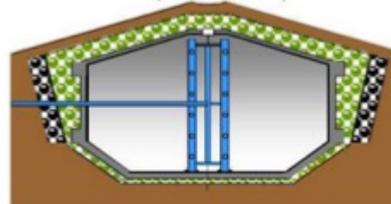
Waste heat and heat storage

Waste heat recovery plant for district heating in Geneva, **not totally used on summer time**

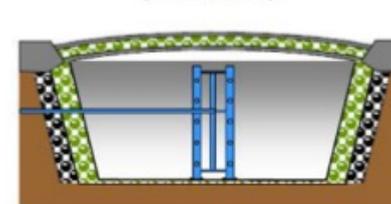
- How increase heat recover on summer time?
 - DH expansion or **heat storage**
- Which kind of heat store?
 - daily x **seasonal** storage
 - **high** x low temperature
 - diffusive, convective or **both** } **ATES** (vs other solutions)



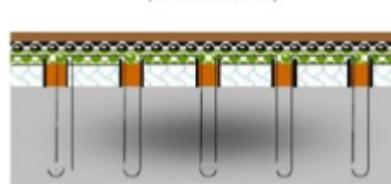
Tank thermal energy storage (TTES) (60 to 80 kWh/m³)



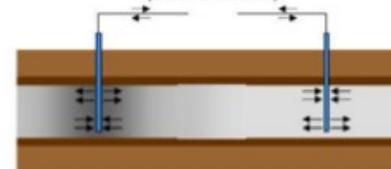
Pit thermal energy storage (PTES) (60 to 80 kWh/m³)



Borehole thermal energy storage (BTES) (15 to 30 kWh/m³)



Aquifer thermal energy storage (ATES) (30 to 40 kWh/m³)

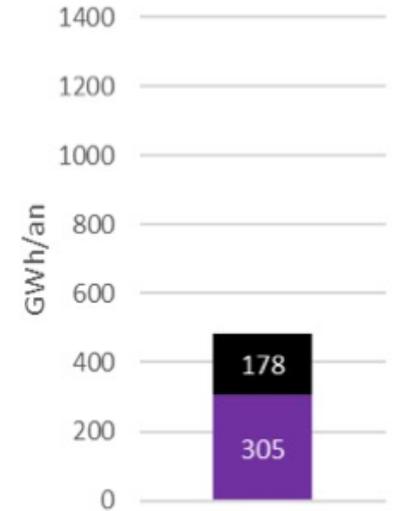
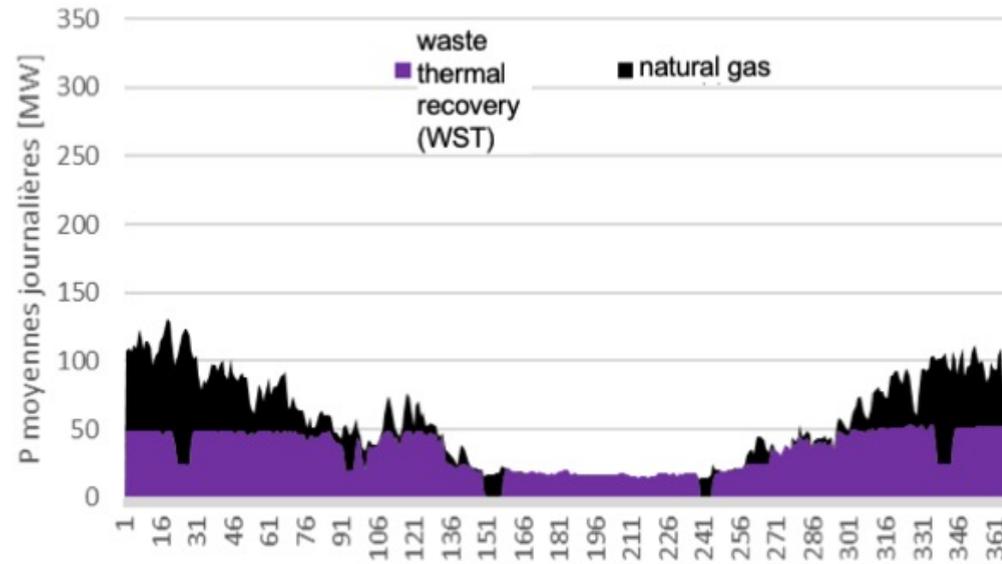


[tools.smartsteep.eu/wiki/Thermal_energy_storage_\(short_and_long_term\)](https://tools.smartsteep.eu/wiki/Thermal_energy_storage_(short_and_long_term))

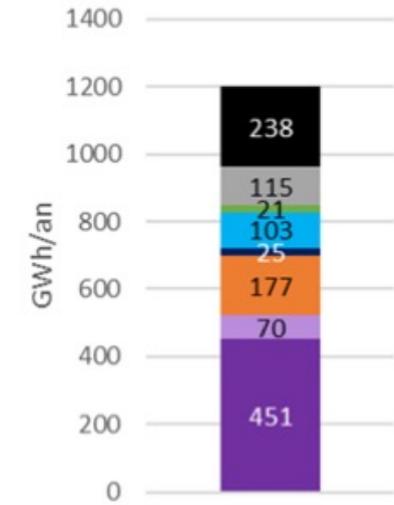
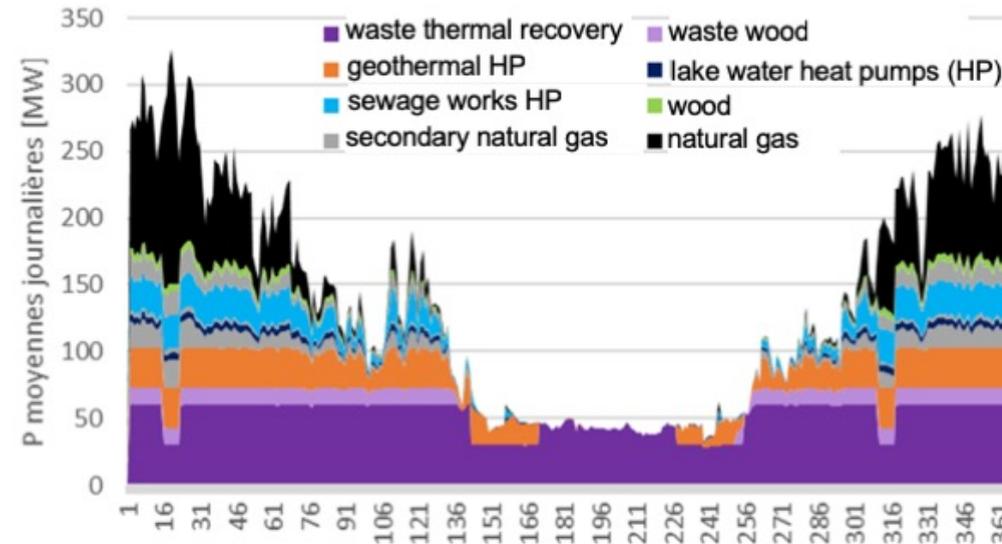
de Oliveira and Hollmuller, 2018; Quiquerez, 2018

Load curves of the main Canton of Geneva networks by 2035

- Load curves Remote Heating SIG 2017



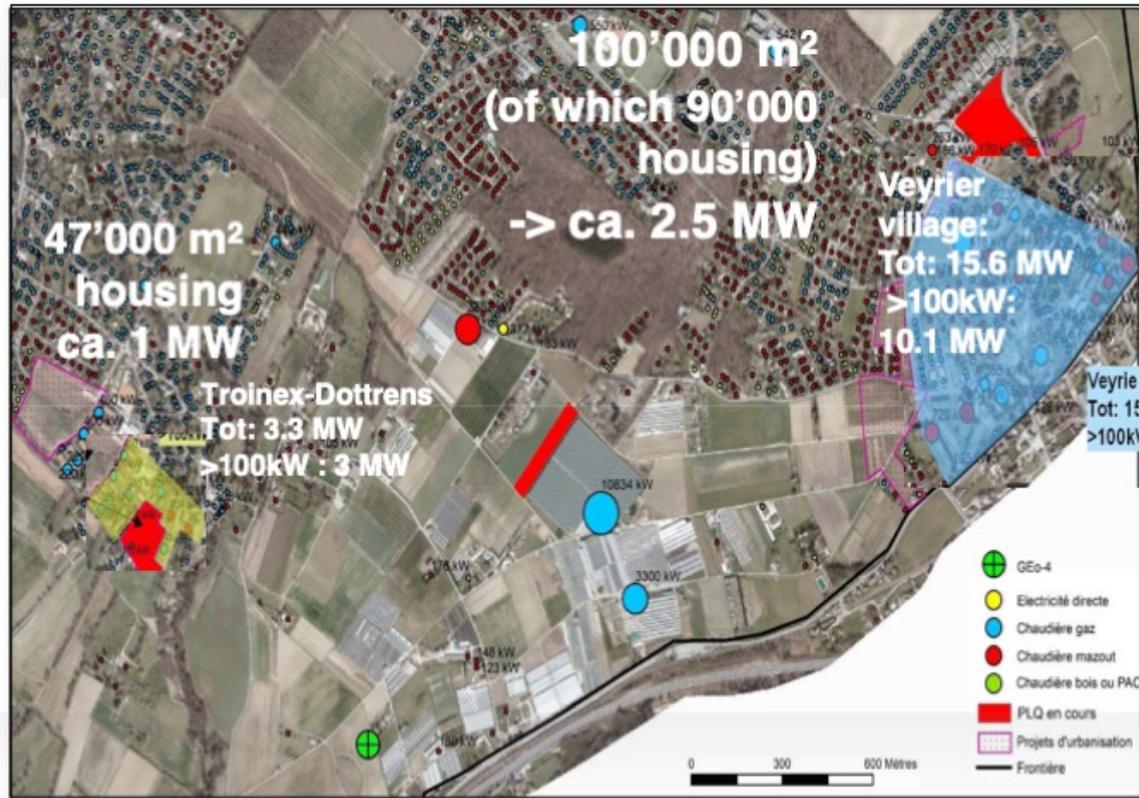
- Load curves Remote Heating 2035 SIG
30 MW geothermal scenario



- Geothermal:**
- 15% of supply
 - Saved 53 ktCO₂

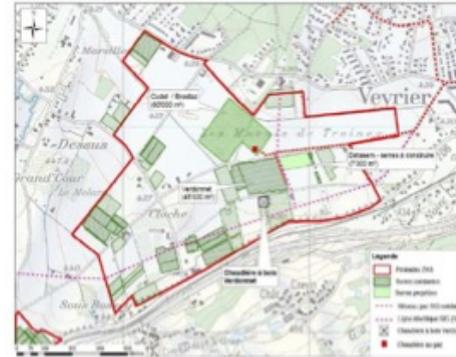
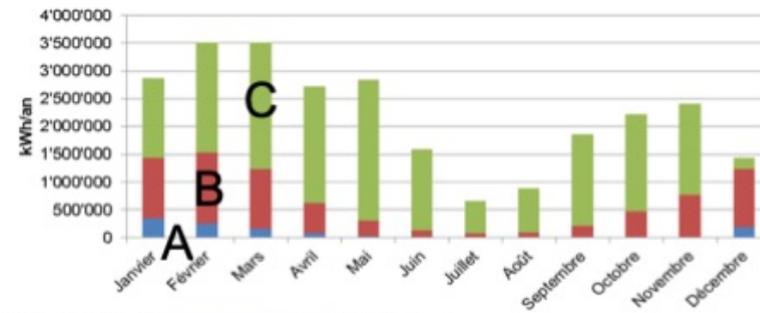
Quiquerez, 2018

Energy need to supply new neighborhood and vegetable farmers: combination of medium-depth direct use of geothermal heat and HP



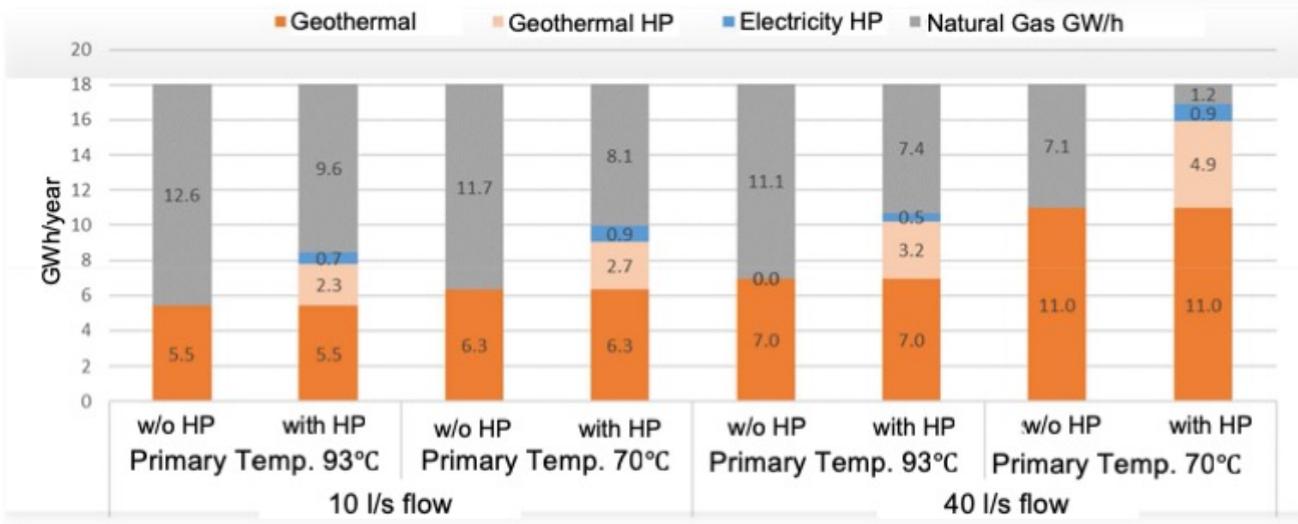
Quiquerez, 2018

Thermal Need from 3 Green House Farms



Cf. étude CSD (2014)

A: 1 GWh/an
B: 7 GWh/an
C: 18 GWh/an



Opportunities & Challenges

- Favourable political, economic and social context
- Integrated and complex approach between direct use of heat from lake water, shallow, medium-depth and future deep subsurface, waste incineration and heat storage: stakeholder management
- Favorable geothermal gradient for hydrothermal direct use and EGS
- Overall favorable subsurface geology despite lateral prediction of reservoir properties require more investigation
- Repeated success is required to continue the geothermal exploration effort (Public have not EPX mindset)
- Exploration mindset education amongst stakeholders is an ongoing effort.
- and...

UNIGE WORKFLOW



SCIENTIFIC & TECHNICAL COMMITMENT

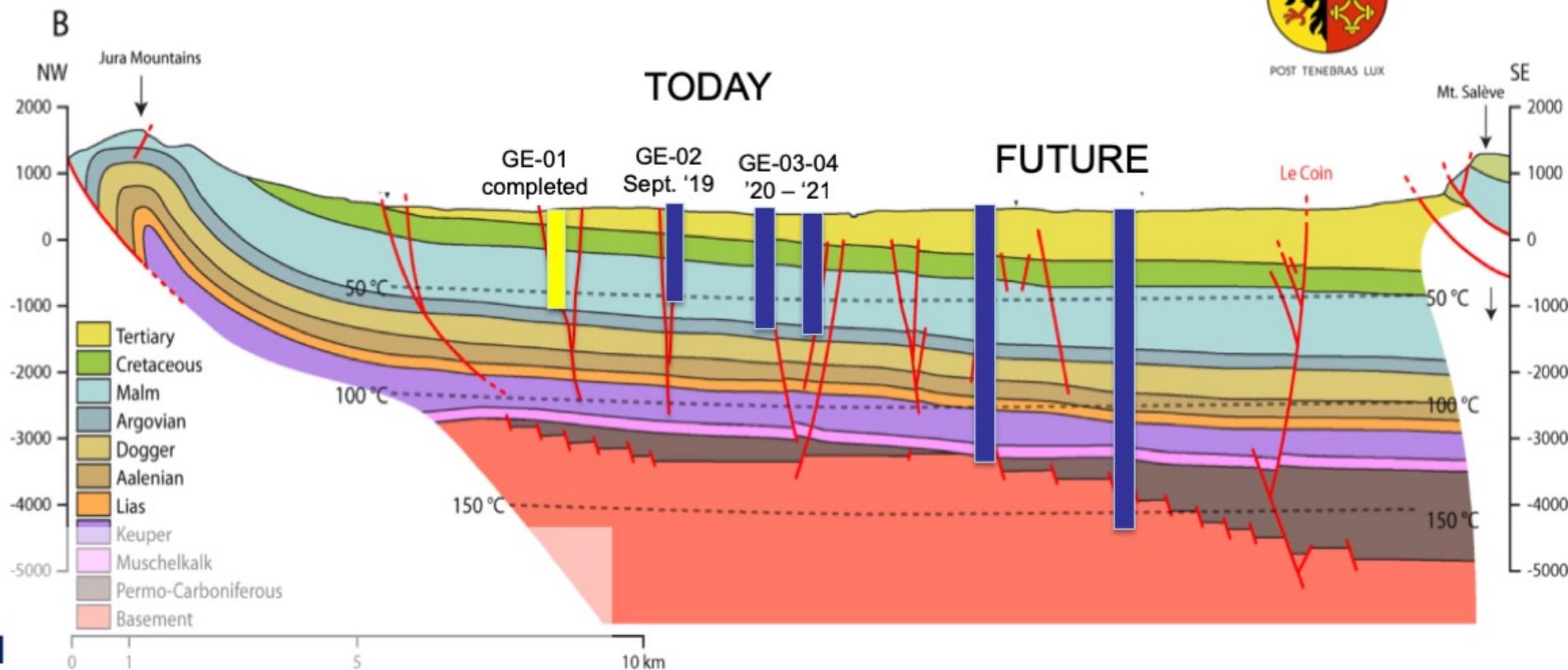


COMMUNITY ENGAGEMENT

Gather full support and endorsement for geothermal exploration efforts (seismic acquisition campaign etc.)



GENEVA CANTON EXPLORATION STRATEGY



Key words

- STEPWISE APPROACH
- UNCERTAINTY IDENTIFICATION
- STRATIGRAPHIC & PRODUCTION TEST
- INNOVATIVE COLLABORATIVE RESEARCH PROJECTS
- ACTIVE FIELD LAB
- POLITICAL, SOCIAL AND COMMERCIAL BUY-IN



AAPG & IGA

3rd Hydrocarbon-Geothermal Cross Over Technology Workshop

Geneva, Switzerland

9-10 April, 2019

Acknowledgments:



N. Clerc, M. Brentini, E. Rusillon, L. Guglielmetti, O. Eruteya, S. Omodeo Salé, D. Do Couto, K. Hong, L. Perozzi, Y. Makhloufi, A. De Haller, G. Ferreira, F. de Oliveira, P. Hollmuller, M. Mayer, C. Nawratil De Bono, F. Martin, L. Quiquerez, N. Andermatten, G. Siddiqi, Heatstore, GECOS, SIG, SFOE, Swisstopo, Geothermal Team @ UNIGE

THANK YOU !